Heat Transfer and Onset of Convection in a Very Compressible Fluid

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The heat transfer has been studied in a Rayleigh-Bénard cell filled with fluid ^{3}He at the critical density over the reduced temperature range $5x10^{-4} < \varepsilon < 0.2$ where $\varepsilon = (T-T_C)/T_C$ with $T_C = 3.316$ K. The experiment consisted in measuring the temperature difference $\Delta T(t)$ across the fluid layer as a function of time after turning on a constant vertical heat current *q*. The height of the fluid layer was 1 mm and the aspect ratio $\Gamma = 57$. In the steady state, the thermal conductivity in the non-convective state and the onset of convection were determined, and measurements were made of $\Delta T(t =)$ as a function of *q* up to reduced Rayleigh numbers $(Ra-Ra_C)/Ra_C$ of the order of $5x10^3$. The onset of convection at the critical Rayleigh number Ra_C agreed well with predictions combining the Schwarzschild and Rayleigh criteria. The transient measurements of $\Delta T(t)$ in the non convective regime were in very good agreement with predictions based on the theory by Onuki and Ferrell. As *q* is increased beyond the onset of convection, unusual damped oscillatory pattern in $\Delta T(t)$ are observed until the steady state is reached. These pattern evolve as the Rayleigh number increases, and leads to some zones characterized by different pattern in the $[\Delta T(t), \varepsilon]$ plane. The power spectrum in the convective regime will also be discussed.